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ABSTRACT

This study evaluated professional outcomes for graduates of the 32 programs supported by the National Institute of General Medical Sciences under the Medical Scientist Training Program (MSTP). Specifically, it evaluated the success of MSTP graduates in establishing research careers and the types of careers and research activities followed compared to graduates of other combined-degree or Ph.D. programs. Data were from National Institutes of Health data bases and curricula vitae provided by graduates of MSTP programs and members of comparison groups. Findings indicated that MSTP graduates are more likely than comparison groups to have received postdoctoral research training support, to hold academic appointments, to have received research support, to have applied for and obtained NIH research grants, and have more total publications and more recent publications. Analysis indicated MTSP graduates are most similar to non-MSTP M.D.-Ph.D.s from the same institutions. Overall, the comparison suggests that MTSP graduates more closely integrate their research activities with medical practice. Individual sections of the report provide background information, detail on the study design, and present findings on educational and career outcomes and professional and research activities. Four appendices include a list of academic department classifications, additional methodology information, definitions and criteria, and statistical tables. (Contains 32 references.) (DB)

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NIGMS

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The Careers and Professional Activities of Graduates of the NIGMS Medical Scientist Training Program

U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
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Summary

The National Institute of General Medical Sciences (NIGMS) established the Medical Scientist Training Program (MSTP) in 1964 to support research training leading to the combined M.D.-Ph.D. degree. The program was designed to train investigators who could better bridge the gap between basic science and clinical research by providing both graduate training in the biomedical sciences and clinical training offered through medical schools. What began in 1964 with three programs has now grown to 32 MSTP programs. Since the inception of the MSTP, several assessments documenting the success of the programs have been conducted, but none included graduates of all the funded MSTP programs, and no recent study has provided data on the career outcomes of comparison groups. In addition, no study has assessed the contribution of combined-degree training to graduates' careers through a comparison between MSTP graduates and other Ph.D. recipients in the biomedical sciences.

This study was designed to assess the success of MSTP graduates in establishing research careers and the types of careers and research activities of MSTP graduates compared to graduates of other combined-degree or Ph.D. programs. The data were drawn from existing National Institutes of Health (NIH) databases as well as from *curricula vitae* (*c.v.*) provided by graduates of MSTP programs and members of several comparison groups. The comparison groups included former MSTP-supported trainees who completed an M.D. but did not complete a Ph.D. degree, Ph.D.-degree recipients supported through traditional NIH training programs, M.D.-Ph.D.-degree recipients from MSTP institutions who were not supported as MSTP trainees, and M.D.-Ph.D.-degree recipients from non-MSTP institutions.

How successful are MSTP graduates in establishing research careers?

By several measures, MSTP graduates appear to have been successful in establishing research careers, and their recent publication records suggest that members of all cohorts continue to be productive researchers. In this regard, the findings of this study are consistent with reports of the individual MSTP programs that have conducted their own studies. When compared to other M.D.-Ph.D. recipients and MSTP trainees who did not complete the Ph.D., MSTP graduates:

- are more likely than most other groups to have received postdoctoral research training support, and more likely to have performed both research and clinical postdoctoral training;
- are more likely than most other groups to hold academic appointments;
- are more likely than other groups to have received research support (from any source);
- are more likely to apply for NIH research grants and, when they do so, are more likely to be successful—three-fourths of MSTP graduates who applied were successful in obtaining NIH support; and
- have more total publications and more publications during the most recent 3-year period for which data are available.

MSTP graduates are also more likely than Ph.D. graduates to hold academic appointments and to have received research support from any source. On many other measures, MSTP graduates do not differ from other NIH-supported trainees who graduate from traditional Ph.D. programs. However, the latter is a select group of graduates who themselves have been shown to be more successful than Ph.D. recipients who have not received NIH research training support.[1]

In what ways do the careers and research activities of MSTP graduates differ from those of graduates of other combined-degree or Ph.D. programs?

Several differences between MSTP graduates and members of the comparison groups emerge when selected characteristics of their professional activities are examined. In terms of these characteristics, MSTP graduates appear most similar to non-MSTP M.D.-Ph.D.s from the same institutions—both groups are likely to be employed in academia with appointments in a clinical or in both a clinical and a basic science department, and both have similar patterns of publication in clinical or mixed-type publications. Such similarities are not surprising, particularly given that individuals in the non-MSTP group participated in many of the same core training activities as their MSTP counterparts, were expected to complete the same degree requirements, had many of the same career aspirations (e.g., pursuing an academic career), and most likely benefited from the MSTP-sponsored training efforts (e.g., seminars and speakers) at those institutions.

Compared to MSTP graduates, MSTP trainees who received only an M.D. degree and M.D.-Ph.D.s from non-MSTP institutions appear to have less research-intensive careers. They are less likely to have research support and academic appointments and are more likely to be engaged in an independent private or group practice. Consistent with this, they have lower rates of publication.

MSTP graduates are more likely than Ph.D. graduates to be employed in academia and are more likely to be located in clinical departments or to have appointments in both a clinical and a basic science department. A high proportion of MSTP graduates complete internship and residency training and many have positions with some clinical involvement. They also are more likely than Ph.D.s to publish in clinical journals or journals that publish both clinical and basic research articles.

These differences reveal a pattern of professional and research activity that differs from that of graduates of traditional research training programs. The settings in which MSTP graduates work and the avenues through which MSTP graduates communicate the results of their research suggest a closer integration of their research activities with the practice of medicine. Although their involvement in patient care may be lower than that of other groups of M.D.-degree recipients, it appears that their clinical interests and training have influenced the nature of their research, and the research training they received through the MSTP contributed to their ability to mount successful research programs relevant to human health and disease.

Introduction

The National Institute of General Medical Sciences (NIGMS) established the Medical Scientist Training Program (MSTP) in 1964 to support research training leading to the combined M.D.-Ph.D. degree. The program was designed to train investigators who could better bridge the gap between basic science and clinical research by providing both graduate training in the biomedical sciences and clinical training offered through medical schools. What began in 1964 with three programs has now grown to 32 MSTP programs funded through the National Research Service Act.[2] In FY 1996, the MSTP supported approximately 870 students, of which about 240 were new trainees appointed that year.[3]

Since the inception of the MSTP, several assessments of the programs have been conducted, including those by NIGMS,[4] the National Research Council (NRC) and the Association of American Medical Colleges (AAMC),[5] and some of the MSTP-funded institutions themselves.[6,7,8,9] The career outcomes of graduates from eight MSTP programs were summarized by Martin in 1991.[10] These studies documented the success of MSTP graduates in establishing research careers, but none of the studies included graduates of all funded MSTP programs, and no study since the 1981 NRC/AAMC study (which included only the first 53 MSTP graduates) provided data on the success of comparison groups.

Three studies attempted to distinguish the nature of the research activities of MSTP graduates from those of other groups of M.D. and M.D.-Ph.D. recipients.[5,11,12] However, in only one of these studies were the careers of MSTP graduates compared to those of other Ph.D. recipients in the biomedical sciences.[12] Contrasting these two groups may help distinguish MSTP graduates from more traditional biomedical Ph.D. recipients in terms of their employment settings, their involvement in both research and clinical practice, the sponsors of their research, and the types of journals in which they publish.

This study was designed to assess the success of MSTP graduates in establishing research careers and the types of careers and research activities of MSTP graduates compared to graduates of other combined-degree or Ph.D. programs. The data were drawn from existing National Institutes of Health (NIH) databases as well as from *curricula vitae* (*c.v.*) provided by graduates of MSTP programs and members of several comparison groups.

Background

Previous studies have consistently demonstrated the success of MSTP graduates in pursuing careers in academic medicine and research. In his review, Martin[10] found that more than 90 percent of the MSTP graduates from the eight programs surveyed who had completed postgraduate training had obtained positions in academia or research institutes (among the programs publishing their own studies, the proportion ranged from 74 percent[7] to 95 percent[9]). This is consistent with the results from a survey of early MSTP graduates.[5] Of those graduates

who entered academia, the available information suggests that a large majority hold appointments in clinical departments, and most have clinical responsibilities.

MSTP graduates have also been shown to be active in research and successful in obtaining NIH support for these efforts. The estimated proportion of graduates entering research careers ranges from 74 percent (reported in the NRC/AAMC study) to virtually all graduates surveyed in some of the studies conducted by individual MSTP institutions. In the NRC/AAMC study, MSTP graduates and comparison groups of M.D.s who had received other forms of NIH training support all had high rates of success in obtaining NIH research support. However, MSTP graduates were more likely than other groups to apply for funding in the first place.

In a small number of studies, an attempt was made to characterize the type of research conducted by MSTP graduates and comparison groups of physician-investigators. The NRC/AAMC study found that MSTP graduates were less likely than other groups of physician-investigators to publish in journals containing high proportions of clinical observations and clinical studies. Based on a sample of 82 MSTP graduates from three research-oriented medical schools, Ahrens also concluded that the majority of their publications focused on non-clinical research rather than clinical or patient-oriented topics.[11] More recently, Sutton and Killian found that applications for NIH research grants submitted by MSTP graduates were as likely to be classified as "laboratory research" as were proposals from applicants who had received only the Ph.D. degree.[12]

Different definitions have been used to distinguish clinical from non-clinical or laboratory research in these studies. The inclusion of human subjects is sometimes among the criteria used to make this distinction. For example, in the study by Sutton and Killian, clinical and laboratory research grant applications were distinguished using a definition of patient-oriented research developed by the NIH Division of Research Grants Clinical Research Study Group. One of the criteria in this definition is the inclusion of human subjects. While laboratory research projects do not meet this definition of clinical research, they nevertheless may have varying degrees of clinical relevance. In this study, indicators are used that might reveal these distinctions.

Study Design

This study was designed to assess the career outcomes of M.D.-Ph.D. recipients who received MSTP support and to compare these outcomes to those of selected groups of other graduates (both M.D.-Ph.D.-degree holders and Ph.D. recipients). The outcomes chosen reflect postgraduate training and career involvement in research, along with a small set of variables related to involvement in clinical activities (see Appendix III). A set of broad indicators (not simply whether the research involves human subjects) was used to characterize the research activities of MSTP graduates and members of the comparison groups. These variables were limited to those contained in available data sets (e.g., the NIH grant application and award files) and ones that could be reliably extracted from individuals' *curricula vitae*.

MSTP Graduate Population and Sample

The study group population included all individuals who had been MSTP trainees and who met several criteria, which are specified in Appendix II. The 1161 individuals who met these criteria were stratified by year of Ph.D. into four cohorts: 1971-75, 1976-80, 1981-85, and 1986-90.[13] Random samples of approximately 120 individuals were selected from the three most recent cohorts and combined with the 1975 cohort, yielding a final sample size of 410.[14] Some characteristics of the MSTP graduates sample and the comparison groups (defined below) can be found in Appendix Table 2 (in Appendix IV).

Comparison Groups

Four comparison groups were constructed as follows (a more detailed description of the construction of these groups is provided in Appendix II):

MSTP M.D. Only (n=269). This group consisted of all MSTP participants who earned the M.D. degree but did not complete the Ph.D. degree. Because the number in each cohort was relatively small, all individuals meeting these criteria were included in the study. [15]

Ph.D. Graduates (n=398). For each sampled MSTP graduate, a Ph.D. recipient who had been supported on a non-MSTP NIH training grant for a minimum of 12 months was selected who matched the MSTP trainee on: 1) Ph.D.-granting institution, 2) year of receipt of Ph.D. degree, 3) field of Ph.D. degree, and 4) gender.[16]

Non-MSTP M.D.-Ph.D.s from MSTP Institutions (n=314). This group consisted of all M.D.-Ph.D.-degree holders who graduated from the same institutions as the MSTP graduates, but who did not receive MSTP support. No individuals from the earliest cohort (1971-75) were identified.[17]

M.D.-Ph.D.s from Non-MSTP Institutions (n=314). This group consisted of M.D.-Ph.D.-degree holders from institutions without MSTP training programs. No individuals were found for the 1971-75 cohort.[17] The study included a random sample from the population of 380 individuals who were identified.

Data Sources

Data on postdoctoral training and career outcomes were drawn from two sources. Existing NIH databases were used to collect records of NIH fellowship and research grant applications and awards for the entire sample of individuals selected for the study. (Complete application and award records were available for fellowships through fiscal year 1995 and for research grants through fiscal year 1996.)

Additional information was extracted from the *curricula vitae* of the sampled individuals. Individuals were contacted by telephone or e-mail and asked to supply a current *curriculum vitae* that included positions held since graduation, publications, and sources and dates of any grant support. The *curricula vitae* were also used to acquire information on postdoctoral fellowships, clinical internships and residencies, and involvement in clinical activities. In order to standardize data that might be affected by the passage of time (e.g., publication records), only those activities occurring through 1995 were recorded from the *curricula vitae* and used in the analyses.

Curricula vitae were received from approximately two-thirds of the total sample. The number of *curricula vitae* received and the proportion that they represent of the total sample (after making any necessary group reassignments based on more accurate degree information) are shown in Appendix Table 4 (in Appendix IV). The group from whom *curricula vitae* were received (shown in Appendix Table 3 of Appendix IV) was comparable to the original sample with respect to gender, race/ethnicity, and field of Ph.D.

Educational and Career Outcomes

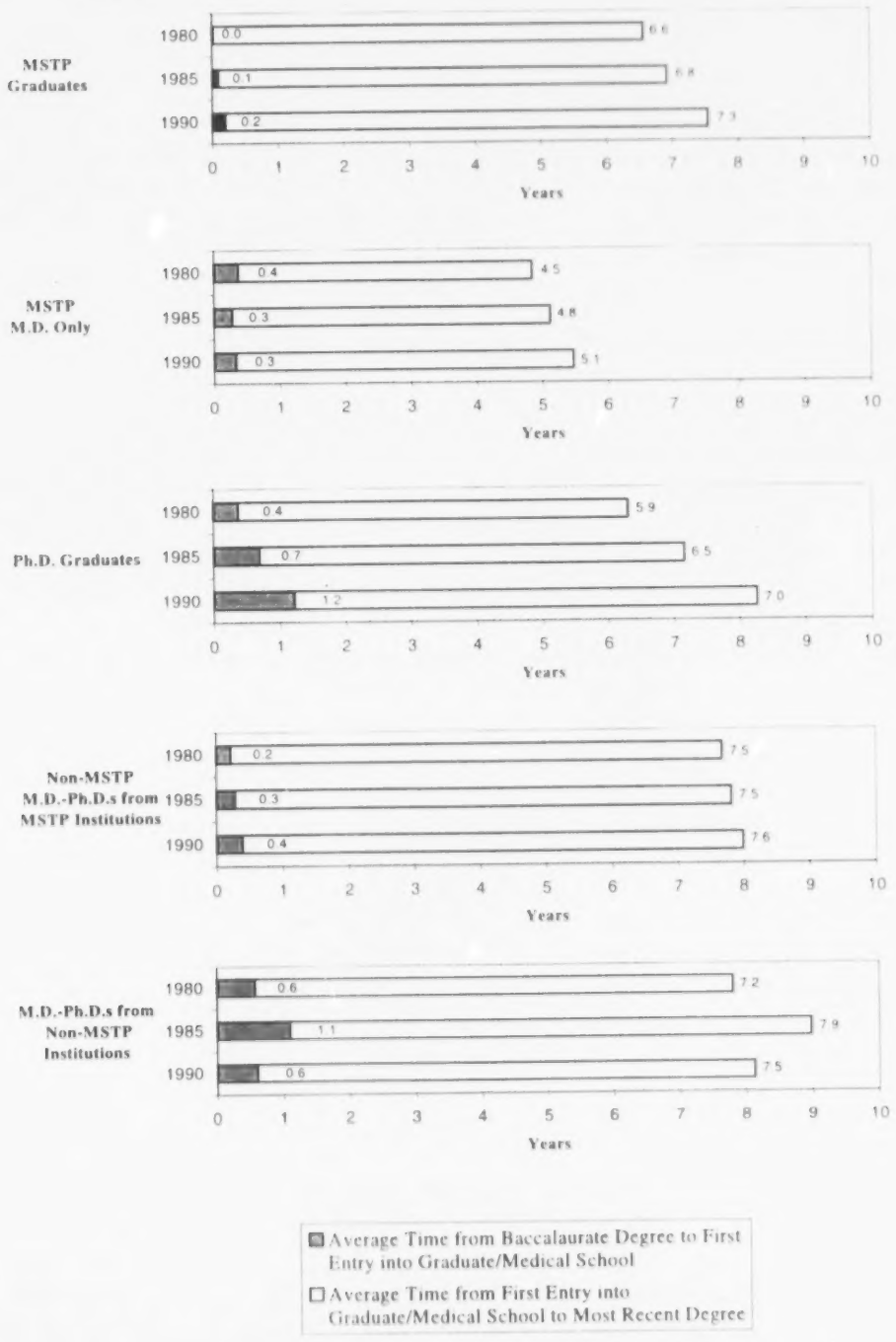
Several measures were used to evaluate the success of MSTP graduates and members of the comparison groups in completing their training and establishing research careers. Educational outcome measures assessed include the amount of time elapsed from receipt of the baccalaureate degree to completion of the M.D. and/or Ph.D. degree, and receipt and sponsoring organizations of postdoctoral research training support. For the groups including M.D. recipients, information was also collected on clinical fellowship support and internship and residency training. Career outcome measures assessed include academic employment, application for and award of NIH research grants, the receipt of research support from other organizations, and the number of publications in peer-reviewed journals.[18]

Time to Latest Degree

For each group, the average total time from receipt of the baccalaureate degree to the most recent degree received, be it M.D. or Ph.D., is shown in Figure 1. (The 1975 cohort is not shown because sufficient data on graduate and medical school entry dates were not available.) This period of time is shown divided into two segments: the average time from the baccalaureate degree to entry into graduate or medical school (whichever occurred first) and the time from first entry to the most recent graduate or medical degree.

Compared to the other groups of M.D.-Ph.D. recipients, MSTP graduates entered graduate or medical school sooner after receiving the baccalaureate degree and completed both degrees more quickly after entering. MSTP graduates also began their graduate or medical school training sooner after receiving the baccalaureate degree than did Ph.D. graduates. As expected, MSTP graduates, who must complete both the graduate and medical school curricula, took a longer time from first entering graduate or medical school to complete both degrees than Ph.D. graduates took to complete the Ph.D. degree.[19]

Figure 1. Elapsed Time from Baccalaureate Degree to Latest Degree, in Years (from extant data).*



* Sufficient data not available for 1975 cohort

Clinical Internship and Residency Training

A high proportion of MSTP graduates (92 percent) completed internship and/or residency training, as indicated by their *curricula vitae*. The rates for the comparison groups of M.D.-degree recipients ranged from 96 percent (for both non-MSTP M.D.-Ph.D.s from MSTP institutions and M.D.-Ph.D.s from non-MSTP institutions) to 99 percent of the MSTP M.D. only group. (Only the difference between MSTP graduates and the MSTP M.D. only group reached statistical significance, although the absolute value of this difference is small.)

Postdoctoral Research Training Support

In many biomedical science disciplines, active involvement in research and entry into an academic career require further postdoctoral research training. Although a large portion of postdoctoral training support is provided by NIH, postdoctoral training is also supported by private foundations (e.g., the American Cancer Society and the Howard Hughes Medical Institute) and private industry. The frequency of such training and the various sources of support were examined. In addition, MSTP graduates and members of the other groups were compared as to the receipt of NIH postdoctoral fellowships.

Postdoctoral Research Support from Sources Other than NIH. The percentage of each group undertaking any type of postdoctoral research training support, and the sources of this support as indicated in their *curricula vitae*, are shown in Table 1. (No consistent trends over cohorts were observed, so data have been collapsed across cohorts.) MSTP graduates were as likely to receive postdoctoral support as non-MSTP M.D.-Ph.D.s from the same institutions, but they were more likely to receive support than the MSTP M.D. only group and M.D.-Ph.D.s from non-MSTP institutions. MSTP graduates were less likely to receive postdoctoral support than Ph.D. graduates. Given the role of postdoctoral training in traditional biomedical research careers and the need for M.D.-Ph.D. graduates to complete an internship/residency before pursuing postdoctoral study, this may reflect the career decisions and additional employment opportunities (e.g., clinical practice) of individuals with M.D. training.

There also were some differences between MSTP graduates and other groups in the sources of their postdoctoral research support. For example, most Ph.D. graduates receiving postdoctoral research support received some of this support from NIH (54 percent). In contrast, most MSTP graduates relied on other sources for their postdoctoral research support—only 36 percent of MSTP graduates received their postdoctoral research support from NIH.

NIH Postdoctoral Fellowships. NIH supports postdoctoral training in several ways, including traineeships on institutional training grants and individual fellowships, both of which were included under NIH support in Table 1. Receipt of an individual postdoctoral fellowship from NIH is often considered a distinct achievement, given the competitive nature of these awards and the peer review of the proposed research plan. Information on

NIH postdoctoral fellowship applications and awards was drawn from extant NIH data available through fiscal year 1995 and does not rely on information provided by study participants in their *curricula vitae*. For the purpose of this study, only activated fellowships were included as awards.

The proportion of each group that applied for NIH postdoctoral fellowships through fiscal year 1995 is shown, by cohort, in Table 2. MSTP graduates were more likely to apply for NIH postdoctoral fellowships than the MSTP M.D. only group and M.D.-Ph.D.s from non-MSTP institutions. MSTP graduates applied for fellowships at approximately the same rate as non-MSTP M.D.-Ph.D.s, but at significantly lower rates than Ph.D. graduates.

Table 1. Percent of Respondents Who Reported Postdoctoral Research Support, and Source (from *c.v.* data).

Postdoctoral Support	MSTP Graduates	MSTP M.D. Only	Ph.D. Graduates	Non-MSTP M.D.-Ph.D.s	
				MSTP Institutions	Non-MSTP Institutions
Received Any Support	65%	30%	91%	65%	47%
Source of Support					
NIH	36	40	54	25	48
Other Federal	0	0	4	2	0
Private Industry	4	0	3	3	4
Private Foundation	41	31	37	47	37
Other	48	52	58	48	43

Note: Sources of support may total more than 100% in each column because some individuals received support from more than one source.

Table 2. Percent of Total Sample Who Applied for Individual NIH Postdoctoral Fellowships (from extant data).

Cohort	MSTP Graduates	MSTP M.D. Only	Ph.D. Graduates	Non-MSTP M.D.-Ph.D.s	
				MSTP Institutions	Non-MSTP Institutions
1975	36%	9%	63%	*	*
1980	17	6	53	18%	7%
1985	20	8	64	16	9
1990	20	3	58	11	9

* No 1975 cohort

Only two groups—MSTP graduates and Ph.D. graduates—applied for individual NIH postdoctoral fellowships in sufficient numbers to provide a basis for comparing success rates. The success rates of these two groups (the percent of individual postdoctoral fellowship applicants who received an award) were comparable, with the exception of the 1990 cohort, as shown in Table 3. For both groups, there has been a decline in success rates across cohorts. Although there is a relatively low rate of success among the 1990 cohort of MSTP graduates, the number of applicants is so small (n=25) that the difference between MSTP graduates and Ph.D. graduates from this cohort is not statistically significant.

Table 3. Success Rate of Applicants in Receiving Individual NIH Postdoctoral Fellowships (from extant data).

Cohort	MSTP Graduates	Ph.D. Graduates
1975	59%	68%
1980	60	53
1985	46	45
1990	28	41

The proportion of each group who received individual NIH postdoctoral fellowships is shown in Table 4. Overall, MSTP graduates were more likely to receive individual NIH postdoctoral fellowships than the MSTP M.D. only group and the other M.D.-Ph.D. recipients. MSTP graduates were less likely than Ph.D. graduates to have received individual NIH postdoctoral fellowships.

Table 4. Percent of Each Cohort Who Received Individual NIH Postdoctoral Fellowships (from extant data).

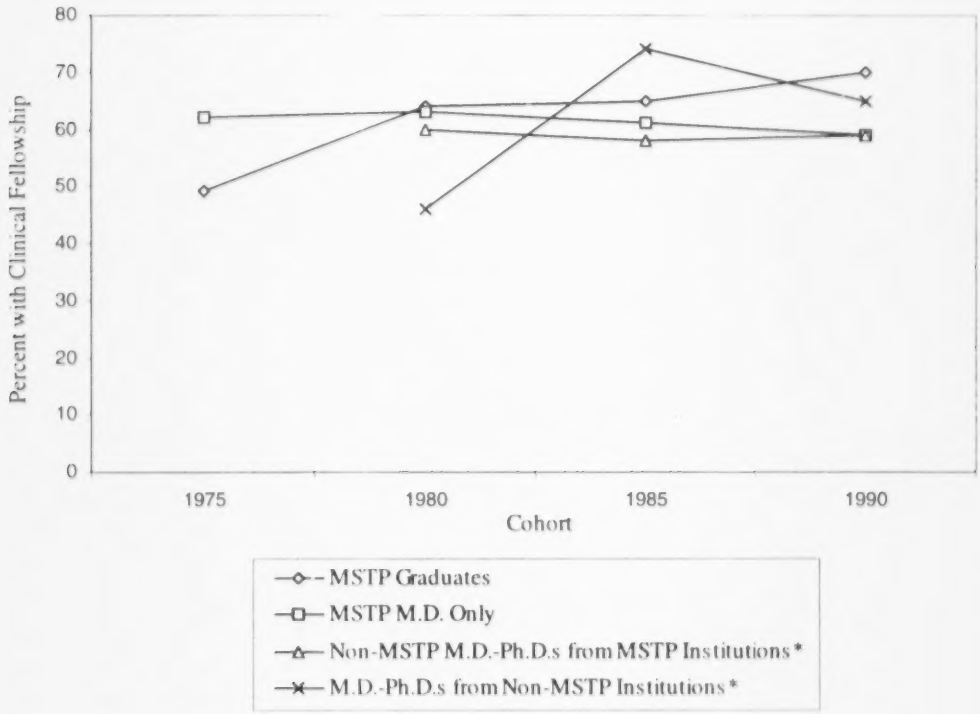
Cohort	MSTP Graduates	MSTP M.D. Only	Ph.D. Graduates	Non-MSTP M.D.-Ph.D.s	
				MSTP Institutions	Non-MSTP Institutions
1975	21%	6%	43%	*	*
1980	10	0	28	5%	4%
1985	9	4	28	7	8
1990	5	3	24	6	4

* No 1975 cohort

Clinical Fellowships

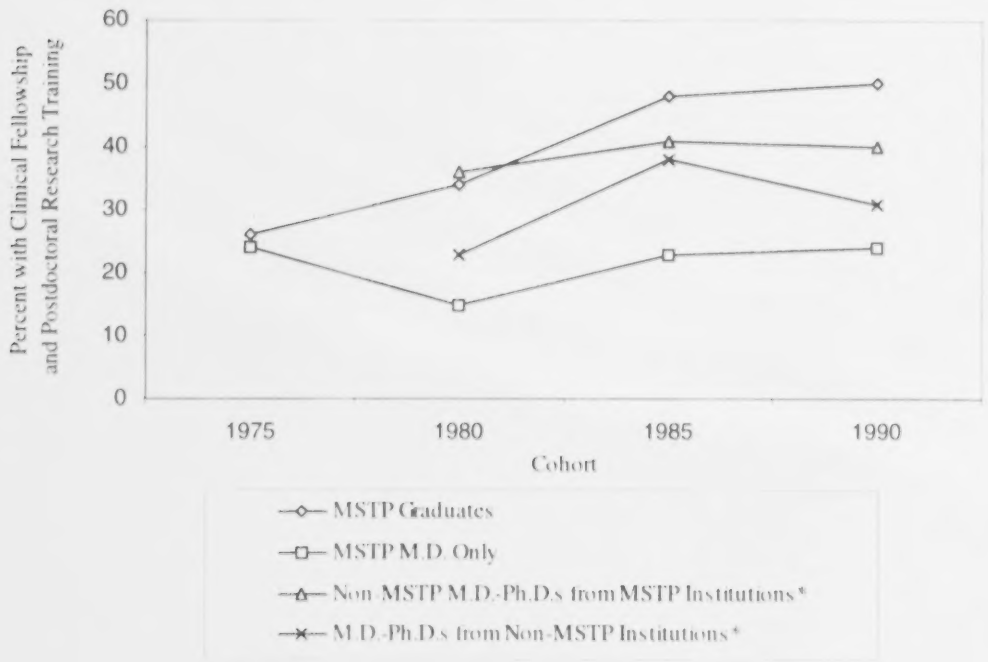
While pursuing a biomedical research career typically involves additional postdoctoral research training, clinical responsibilities generally require further postgraduate clinical specialty training. Differences between the groups of M.D.-degree recipients in the proportion who received this training were small, as shown in Figure 2. However, since 1975, MSTP graduates have been increasingly likely to perform a clinical fellowship. The percentage has increased from about 50 percent of the 1975 cohort to about 70 percent of the 1990 cohort. No similar, consistent trend appears in the comparison groups of M.D. recipients, suggesting that the increased likelihood of clinical training among MSTP graduates is not simply attributable to an overall increase in clinical fellowship training of all M.D.s. The increase among MSTP graduates has also resulted in an increase in the proportion who have undertaken both postdoctoral research training and a clinical fellowship over the same time period (Figure 3). In the most recent (1990) cohort, about 50 percent of MSTP graduates obtained both postdoctoral research training and additional clinical training, compared with 40 percent of non-MSTP M.D.-Ph.D.s from MSTP institutions, 31 percent of M.D.-Ph.D.s from non-MSTP institutions, and 24 percent of the MSTP M.D. only group.

Figure 2. Percent of Each Group Who Performed a Clinical Fellowship (from *c.v.* data).



* No 1975 cohort

Figure 3. Percent of Each Group Who Performed Both Postdoctoral Research Training and a Clinical Fellowship (from *c.v.* data).



* No 1975 cohort

Research Activity

As suggested in previous studies of MSTP programs, data on applications for NIH research grants show that a high proportion of MSTP graduates have pursued research careers. The proportion of each group who applied for NIH research grants through fiscal year 1996 is shown, by cohort, in Figure 4.[20] (Due to the unavailability of data beyond fiscal year 1996, the proportion applying within each group decreases with later cohorts.) MSTP graduates were more likely to apply for NIH research grants than were MSTP trainees who received only an M.D. degree and other M.D.-Ph.D.s, whether they were from an MSTP institution or from non-MSTP institutions.[21] There were no significant differences between MSTP graduates and Ph.D. graduates.

There also were differences among the groups in the number of applicants who were successful in obtaining support (Figure 5). MSTP graduates who applied for NIH research grants were very successful—74 percent eventually received at least one award. In addition, MSTP applicants for NIH research grants were more successful than applicants from the three other M.D. or M.D.-Ph.D. groups (55 percent of applicants from the MSTP M.D. only group, 62 percent of applicants

Figure 4. Percent of Sample Who Applied for NIH Research Grants (from extant data).

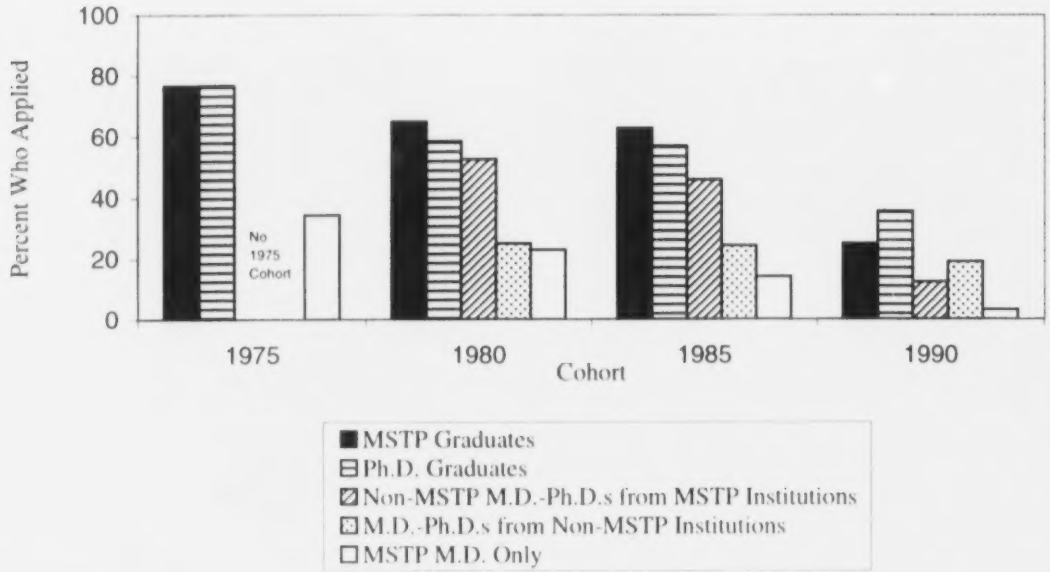
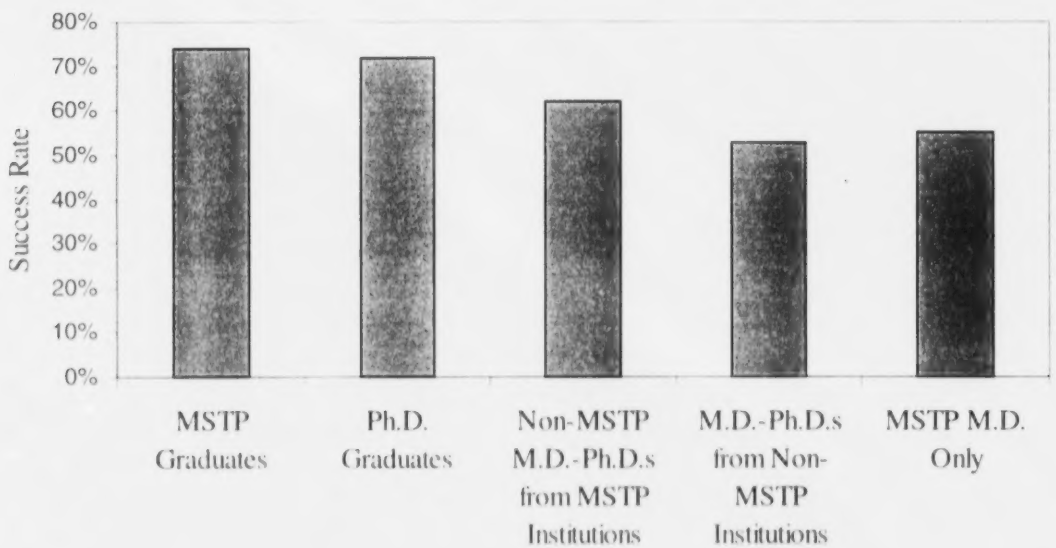


Figure 5. Success Rate of Applicants for NIH Research Grants (from extant data).



from the non-MSTP M.D.-Ph.D.s from MSTP institutions group, and 53 percent of applicants from the M.D.-Ph.D.s from non-MSTP institutions group were successful in obtaining support). Once again, MSTP graduates did not differ significantly from Ph.D. graduates, 72 percent of whom were successful in obtaining funding.

The combined effects of the greater likelihood of MSTP graduates to apply for research grants and their greater success in obtaining funding is reflected in even larger differences between MSTP graduates and the other M.D. and M.D.-Ph.D. groups in the proportion who have ever held an NIH research grant, as shown in Figure 6.

Using the data available from the *curricula vitae* on research support from any source, a similar pattern of results appears, although the differences between MSTP graduates and the three other M.D. or M.D.-Ph.D. groups are generally smaller. The proportion of each group reporting research support from any source is shown in Figure 7.

There are several possible reasons why differences between MSTP graduates and other groups are smaller in the *curricula vitae* data: 1) reports of research support collected through *curricula vitae* can include support as a co-investigator, whereas NIH records identify only the principal investigator; 2) the *curricula vitae* data include receipt of NIH research career development awards, which, although directed at providing new faculty with time for additional research training under a mentor, can also include more independent research roles in the later years of the award; and 3) the *curricula vitae* data include support from any source, which tends to reduce differences to the extent that other groups receive research support from non-NIH sources.

Sources of Research Support

As suggested by the extant NIH research grant data in Figure 6 and the *curricula vitae* data in Figure 7, there are significant differences between the groups in the sources of their research support. Table 5 shows the sources of support for those individuals who reported receiving any research support.[22] Compared to MSTP graduates, the MSTP M.D. only group and the two groups of non-MSTP M.D.-Ph.D.s are less likely to receive their research support from NIH and from private foundations. MSTP graduates reported receiving support from other federal agencies (primarily from the National Science Foundation and the Department of Defense) less often than Ph.D. graduates, and they were more likely than Ph.D. graduates to receive support from private industry (e.g., for pharmaceutical drug trials) and private foundations.

Figure 6. Percent of Total Sample Who Received NIH Research Grants (from extant data).

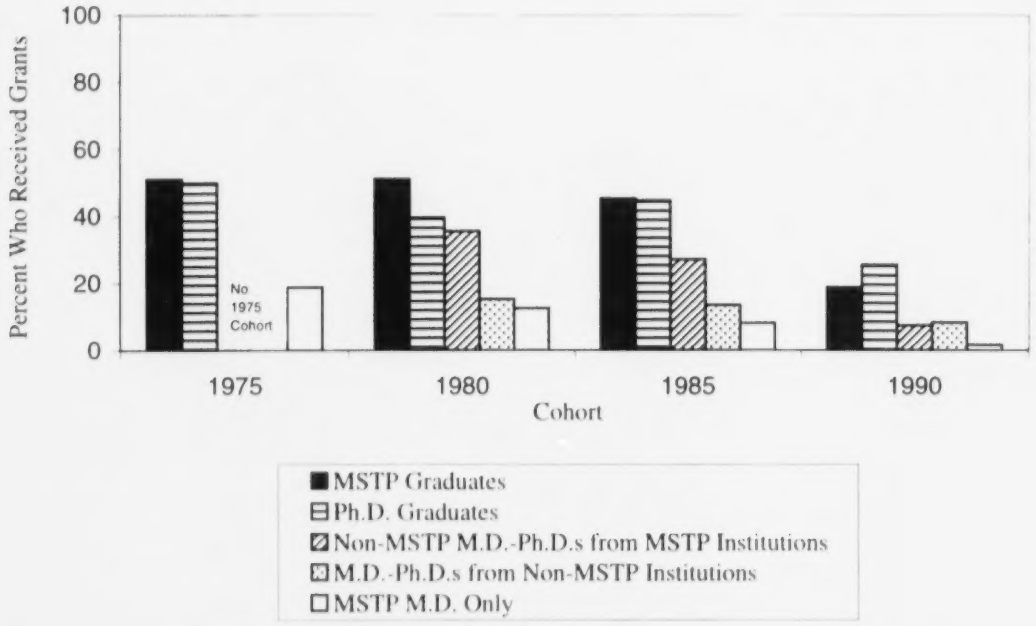


Figure 7. Percent of Respondents Who Reported Research Support from Any Source (from *c.v.* data).

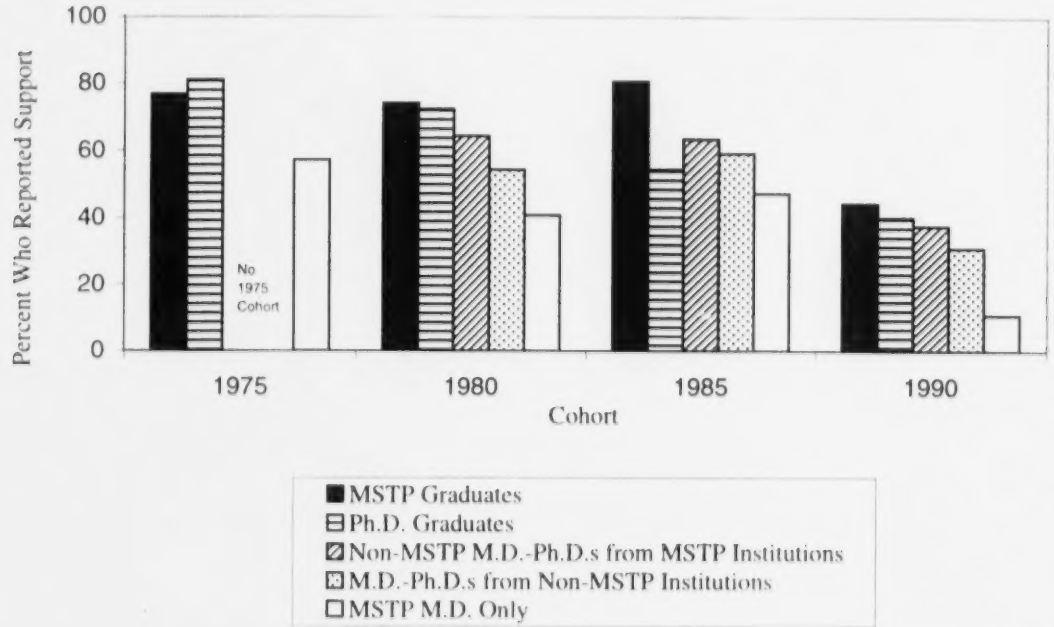


Table 5. Percent of Respondents Who Cited Each Source of Research Support (from *c.v.* data).[22]

Source of Support	MSTP Graduates	MSTP M.D. Only	Ph.D. Graduates	Non-MSTP M.D.-Ph.D.s	
				MSTP Institutions	Non-MSTP Institutions
NIH	78%	60%	76%	65%	61%
Other Federal	19	15	37	19	20
Private Industry	33	40	15	24	41
Private Foundation	74	46	58	62	48
Other	53	46	56	58	52

Publications

The *curricula vitae* were used to gather information on both the total number of articles each individual had published by the end of 1995 and the number published in the years 1993 through 1995. Peer-reviewed and invited articles and reviews were included, but "in press" articles and entries identified by the individual as an editorial, letter to the editor, or book review were excluded. In several respects, the publication data shown in Figure 8 parallel the findings described above under research support. MSTP graduates have more publications than the other groups of M.D.s and M.D.-Ph.D.s (taking into account the effects of cohort on the number of publications), but they do not differ from the group of Ph.D. graduates.[23] MSTP graduates do differ from Ph.D. graduates in the median number of articles published in the most recent 3-year period for which data were available (Figure 9), one measure of the extent to which they are still currently active in research.

Figure 8. Median Number of Articles Published (from *c.v.* data).

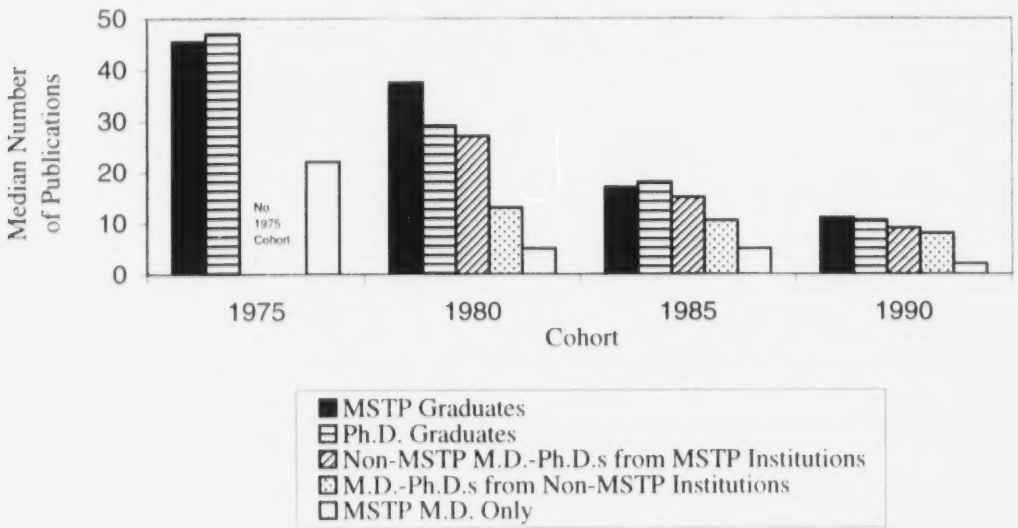
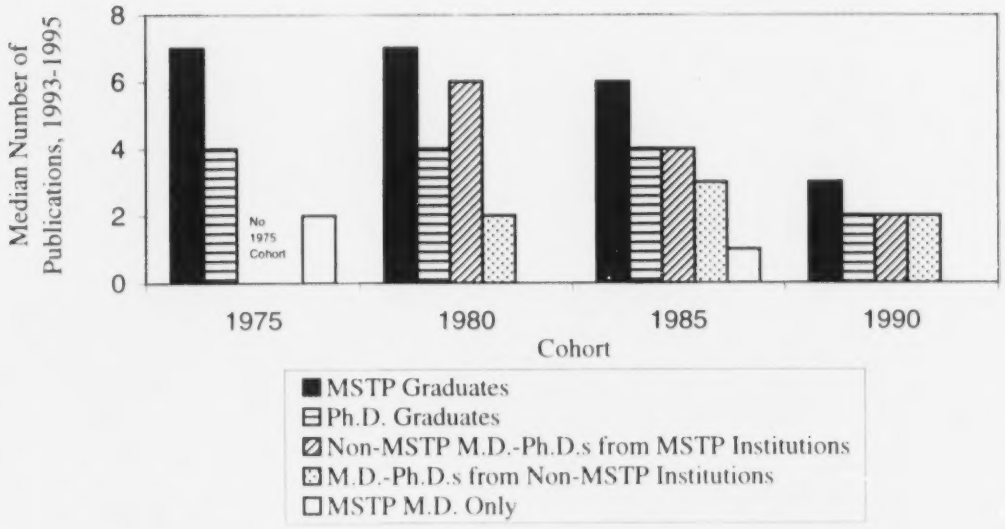


Figure 9. Median Number of Articles Published in 1993-1995 (from *c.v.* data).



Professional and Research Activities

Several characteristics were used to assess the ways in which the careers and research activities of MSTP graduates differ from those of members of the comparison groups. The groups were contrasted with regard to the extent to which they held academic appointments, the type of departments in which those appointments were held, their involvement in clinical responsibilities, and the orientation of the journals in which their research was published.[24]

Academic and Other Types of Appointments

About 83 percent of the MSTP graduates in the study who were employed in 1995 had one or more academic appointments (Table 6). This was a significantly higher proportion than that found in all other groups except for the group of non-MSTP M.D.-Ph.D.s from MSTP institutions. (A breakdown of 1995 employment by cohort and type of organization can be found in Appendix Table 6 of Appendix IV.) Most MSTP graduates also had an organizational affiliation that would indicate some clinical responsibilities, such as a position in a hospital, clinic, or private practice. Moreover, MSTP graduates were less likely than the MSTP M.D. only group and the groups of non-MSTP M.D.-Ph.D.s to be employed in independent private or group practices. MSTP graduates were also less likely than Ph.D. graduates to be employed in private industry.

Table 6. Positions Held in 1995, by Type of Organization (from *c.v.* data).

Type of Organization	MSTP Graduates	MSTP M.D. Only	Ph.D. Graduates	Non-MSTP M.D.-Ph.D.s	
				MSTP Institutions	Non-MSTP Institutions
Academia	83%	64%	65%	79%	67%
Hospital/Clinic	52	58	3	50	54
Private Industry	6	6	30	3	4
Self Emp/Priv Practice	8	31	2	13	24
Other	7	4	9	9	2

Note: Columns total more than 100% because some individuals have positions in more than one type of organization.

There also were differences between MSTP graduates and other groups in the types of departments in which they held their academic appointments (Table 7). Based primarily on classifications found in AAMC publications,[25] departments were classified as either basic science departments or clinical departments (see Appendix I for a classification of academic departments).[26] Members of each group were categorized by whether they held appointments only in basic science departments, only in clinical departments, or in both. MSTP graduates were less likely than the M.D. only group to be only in a clinical department, and less likely than Ph.D. graduates to be only in a basic science department. No significant differences were found between MSTP graduates and the other groups of M.D.-Ph.D. recipients in the type of academic department in which they held an appointment in 1995.

Table 7. Type of Academic Department in Which Academic Positions Were Held in 1995 (from *c.v.* data).

Department Type*	MSTP Graduates	MSTP M.D. Only	Ph.D. Graduates	Non-MSTP M.D.-Ph.D.s	
				MSTP Institutions	Non-MSTP Institutions
Basic	23%	13%	81%	18%	15%
Clinical	52	82	12	58	63
Both	24	5	7	25	22

* See Appendix I for classification of academic departments.

Clinical Activities

Employment information contained in the *curricula vitae*, including both academic and non-academic appointments, indicated that 86 percent of the M.D. recipients from all groups in the study held clinically related positions in 1995.[27] By group, the percentages ranged from 81 for MSTP graduates to 91 for the MSTP M.D. only group; for non-MSTP M.D.-Ph.D.s from MSTP institutions and M.D.-Ph.D.s from non-MSTP institutions, the percentages were 87 and 90,

respectively. (The difference between MSTP graduates and non-MSTP M.D.-Ph.D.s from MSTP institutions did not reach statistical significance.)

Types of Journal Publications

One way of characterizing the research conducted by MSTP graduates and members of the comparison groups is to examine the type of journals in which the results are published. Using categorizations contained in the Institute for Scientific Information (ISI) *Current Contents Journal Coverage as of January 1996*, journals listed in the *curricula vitae* of respondents were grouped into three primary categories: basic (journals classified by ISI as life or other natural sciences), clinical (classified by ISI as clinical medicine), and mixed types (classified by ISI as both life sciences and clinical medicine). Data were collected on the number of articles published by each individual in each of these categories. Table 8 shows, by cohort, the average distribution of publications by journal type.

Table 8. Average Distribution of Publications by Type of Journal (from *c.v.* data).[28]

Cohort	Journal Type	MSTP Graduates	MSTP M.D. Only	Ph.D. Graduates	Non-MSTP M.D.-Ph.D.s	
					MSTP Institutions	Non-MSTP Institutions
1975	Basic	60%	24%	90%	*	*
	Clinical	8	21	4		
	Mixed Types	31	53	6		
1980	Basic	67	44	88	54%	61%
	Clinical	8	12	2	10	10
	Mixed Types	25	43	10	35	30
1985	Basic	77	43	89	64	61
	Clinical	4	17	1	8	10
	Mixed Types	19	35	10	28	28
1990	Basic	83	64	96	78	73
	Clinical	4	8	1	4	7
	Mixed Types	13	28	3	17	18

* No 1975 cohort

Within all groups, most articles appeared in journals classified as either basic or mixed types; relatively few articles appeared in journals classified as clinical. The pattern of results from these publication data is similar to the pattern found in the departmental affiliations shown in Table 7. MSTP graduates do not differ from other M.D.-Ph.D. recipients, but they are more likely to have publications in basic journals than the MSTP M.D. only group, and they are more likely than Ph.D. graduates to have publications in clinical or mixed-type publications. For all of the combined-degree groups, there is a tendency for the publications of recent cohorts (which are

more likely than the publications of older cohorts to represent predoctoral research studies) to be more heavily concentrated in basic journals.

Conclusions

The data presented in the preceding sections are summarized below by the extent to which they address the two questions that were the primary focus of this study:

How successful are MSTP graduates in establishing research careers?

By several measures, MSTP graduates appear to have been successful in establishing research careers, and their recent publication records suggest that members of all cohorts continue to be productive researchers. In this regard, these findings are consistent with reports of the individual MSTP programs that have conducted their own studies. The various measures used in this study and the differences found between MSTP graduates and the comparison groups are summarized in Table 9. When compared to other M.D.-Ph.D. recipients and the MSTP M.D. only group, MSTP graduates have demonstrated greater success on nearly all measures. A high percentage of MSTP graduates are in academic positions, they have been successful in obtaining research support (three-fourths of those who applied were successful in obtaining NIH research support), and they publish actively.[29]

On many measures, MSTP graduates do not differ from other NIH-supported trainees who graduate from traditional Ph.D. programs. However, the latter is a select group of graduates who themselves have been shown to be more successful than Ph.D. recipients who have not received NIH research training support.[1]

In what ways do the careers and research activities of MSTP graduates differ from those of graduates of other combined-degree or Ph.D. programs?

Several differences between MSTP graduates and members of the comparison groups emerge when selected characteristics of their professional activities are examined. A summary of the comparisons of their 1995 employment characteristics and their publication patterns is shown in Table 10. In terms of these characteristics, MSTP graduates appear most similar to non-MSTP M.D.-Ph.D.s from the same institution—both groups are likely to be employed in academia with appointments in a clinical or both a clinical and basic science department, and both have similar patterns of publication in clinical or mixed-type publications. Such similarities are not surprising, particularly given that non-MSTP-supported students at MSTP institutions met the same requirements as their MSTP counterparts for admission to the combined-degree program, participated in many of the same core training activities, were expected to complete the same degree requirements, had many of the same career aspirations (e.g., pursuing an academic career), and most likely benefited from the MSTP-sponsored training efforts (e.g., seminars and speakers, etc.) at those institutions.

Table 9. Comparison of MSTP Graduates to Other Groups on Measures of Research Activity.

Measure of Research Activity	MSTP Graduates Relative to:			
	MSTP M.D. Only	Ph.D. Graduates	Non-MSTP M.D.-Ph.D.s	
			MSTP Institutions	Non-MSTP Institutions
Postdoctoral Training				
% Applied for NIH Postdoctoral Support	>	<	=	>
% Received NIH Postdoctoral Support	>	<	=	=
NIH Postdoctoral Support Success Rate	n/a	=	n/a	n/a
% Received Postdoctoral Support from Any Source	>	<	=	>
% With Internship/Residency Training	<	n/a	=	=
% With Both Research and Clinical Postdoctoral Support	>	n/a	>	>
Research Support				
% Applied for NIH Research Grant	>	=	>	>
% Received NIH Research Grant	>	=	>	>
NIH Research Grant Success Rate	>	=	>	>
% Received Research Support from Any Source	>	>[a]	>	>
Publications				
Total Number	>	=	>	>
Number in 1993-1995 (most recent 3 years)	>	>	>	>
Employment				
% in Academic Positions	>	>	=	>

Note: A > symbol is used to indicate comparisons in which MSTP graduates exceeded the comparison group, a < symbol indicates comparisons in which the comparison group exceeded MSTP graduates, and a = symbol indicates no difference between groups. n/a designates a number that is too small for a reliable estimate or not applicable.

Table 10. Comparison of MSTP Graduates to Other Groups on Selected 1995 Professional Activities and Publication Patterns.

Professional Activity/Publication Pattern	MSTP Graduates Relative to:			
	MSTP M.D. Only	Ph.D. Graduates	Non-MSTP M.D.-Ph.D.s	
			MSTP Institutions	Non-MSTP Institutions
Academic Appointment	>	>	=	>
Appointment in Clinical Academic Department	<	>	=	<
Publications in Clinical or Mixed-Type Journals	<	>	=	<
Clinically Related Employment	<	n/a	=	<
Engaged in Private Practice	<	n/a	=	<

Note: A > symbol is used to indicate comparisons in which MSTP graduates exceeded the comparison group, a < symbol indicates comparisons in which the comparison group exceeded MSTP graduates, and a = symbol indicates no difference between groups. n/a = not applicable to Ph.D. group.

Compared to MSTP graduates, the MSTP M.D. only group and M.D.-Ph.D.s from non-MSTP institutions appear to have less research-intensive careers. They are less likely to have research support and academic appointments, and are more likely to be engaged in an independent private or group practice. Consistent with this, they also have lower rates of publication.

Although both MSTP graduates and NIH-supported Ph.D. graduates appear similar in measures of research activity, MSTP graduates are distinguished from them in several ways, some of which might be expected given their combined-degree training. In addition to being more likely than Ph.D. graduates to be employed in academia, MSTP graduates are more likely to be located in clinical departments or to have appointments in both a clinical and a basic science department, a high proportion complete internship and residency training, and many have positions with some clinical involvement. They also are more likely than Ph.D. graduates to publish in clinical journals or journals that publish both clinical and basic articles.

These differences reveal a pattern of professional and research activity that differs from that of graduates of traditional Ph.D. research training programs. Although the NIH-funded research conducted by MSTP graduates may be "laboratory-oriented" as frequently as the research of Ph.D. graduates (as suggested by Sutton and Killian's findings),[12] the settings in which they work and the avenues through which MSTP graduates communicate the results of their research suggest a closer integration of their research activities with the practice of medicine. Although their involvement in patient care may be lower than that of other groups of M.D.-degree recipients, it appears that their clinical interests and training have influenced the nature of their research, and that the research training they received through the MSTP contributed to their ability to mount successful research programs relevant to human health and disease.

Notes and References

[1] National Institutes of Health. NIH predoctoral research training in the biomedical and behavioral sciences: outcomes for 1982-92 Ph.D.s. Report in preparation.

[2] The National Research Service Act was initially passed in 1974 and is the current authorizing legislation for the National Institutes of Health's research training programs.

[3] See Appendix Table 1 (in Appendix IV) for annual data on funded programs.

[4] National Institute of General Medical Sciences. MSTP evaluation. NIGMS Publication No. 79-401. Bethesda, MD: NIGMS, NIH, 1980.

[5] Sherman CR, Jolly HP, Morgan TE, Higgins EJ, Hollander D, Bryll T, Sevilla ER. On the status of medical school faculty and clinical research manpower, 1968-1990: a report to the clinical sciences panel of the committee on a study of national needs for biomedical and behavioral research personnel. NIH Publication No. 82-2458. Bethesda, MD: NIH, 1981.

[6] Bradford WD, Pizzo S, Christakos AC. Careers and professional activities of graduates of a medical scientist training program. *Journal of Medical Education* 1986;61:915-8.

[7] Bradford WD, Anthony D, Chu CT, Pizzo SV. Career characteristics of graduates of a medical scientist training program, 1970-1990. *Academic Medicine* 1996;71:484-7.

[8] Frieden C, Fox BJ. Career choices of graduates from Washington University's Medical Scientist Training Program. *Academic Medicine* 1991;66:162-4.

[9] McClellan DA, Talalay P. M.D.-Ph.D. training at the Johns Hopkins University School of Medicine, 1962-1991. *Academic Medicine* 1992;67:36-41.

[10] Martin JB. Training physician-scientists for the 1990s. *Academic Medicine* 1991;66:123-9.

[11] Ahrens EH Jr. The crisis in clinical research: overcoming institutional obstacles. New York: Oxford University Press, 1992.

[12] Sutton J, Killian CD. The M.D.-Ph.D. researcher: what species of investigator? *Academic Medicine* 1996;71:454-9.

[13] Throughout this report, cohorts are referred to by the last year of each of these ranges. For example, the 1975 cohort refers to graduates who received their Ph.D. degrees in 1971 through 1975.

[14] All individuals in the 1971-75 cohort were selected due to its small sample size (n=51).

[15] Some reassignments among groups were necessary as a result of more complete information on degree status contained in *curricula vitae* collected from study participants. For example, 25 individuals originally in the MSTP M.D. only group were found to have received Ph.D. degrees and were either reassigned to the MSTP graduates group or were excluded from the study for not having received coterminous degrees by 1990.

[16] See Appendix II for a more detailed description of the matching procedures.

[17] This is partly attributable to problems with the completeness of M.D. degree data prior to 1980, which may have also affected the accurate identification of the 1975-79 cohort and the degrees received.

[18] In addition to participation in an MSTP training program, these outcome measures could be influenced by other differences between MSTP graduates and members of the comparison groups. For example, among those individuals for whom *curricula vitae* were available, MSTP graduates differed from some of the comparison groups in certain respects: compared to the M.D. only group, a smaller proportion of MSTP graduates were female; compared to Ph.D. graduates, a larger proportion of MSTP graduates were underrepresented minorities; and MSTP graduates received, on average, more months of NIH predoctoral training support than the comparison groups consisting of former NIH trainees. MSTP graduates also differed from M.D.-Ph.D.s from non-MSTP institutions in their field of Ph.D. (for example, M.D.-Ph.D.s from non-MSTP institutions were more likely than MSTP graduates to receive Ph.D. degrees in pharmacology). Although differences in the field of Ph.D. degree could be related to differences in publication patterns and other outcomes, sample sizes (relative to the number of field categories) were too small to permit adjustments for group differences on this variable. An attempt was made to cluster degree fields into a smaller number of categories that might account for differences between these groups in publications, but no consistent relationship across cohorts between field of degree and number of publications was found. For most of the outcome measures examined, gender, race/ethnicity, and months of NIH research training support were included as covariates in the analyses and any effects they had on the results are noted.

[19] Due to the skewed distribution of these data, nonparametric analyses were used to compare groups.

[20] Records of NIH research project grant applications and awards identify only the principal investigator. Co-investigators and principal investigators of subprojects in program project or center grants are not included in these data.

[21] The difference between MSTP graduates and graduates of non-MSTP institutions did not reach statistical significance in the 1990 cohort. However, these data are the most severely curtailed due to the unavailability of grant application records beyond fiscal year 1996.

[22] See Appendix III for definitions and examples of sources of support.

[23] To adjust for skewness in the publications data, comparisons between groups were based on the log number of publications. Summary statistics for numbers of publications by group and cohort are shown in Appendix Table 5 in Appendix IV.

[24] Nearly all respondents in this study were employed in 1995 (the latest year for which data were collected) except the most recent cohort of graduates, of whom about 70 percent were employed. Those who were not employed were engaged in postdoctoral study or additional clinical training.

[25] See, for example, Table C2 of AAMC data book: statistical information related to medical education. Washington, DC: Association of American Medical Colleges, 1998.

[26] A small percentage of appointments (1 percent) were unclassified.

[27] Clinically related positions include those with some form of clinical activity (see Appendix III for definition) and appointments in clinical academic departments.

[28] Not shown are small percentages of publications in a fourth category consisting of social and behavioral science journals. These publications represented less than 1 percent of all publications.

[29] Some portion of these differences between MSTP graduates and the comparison groups may be attributable to factors other than the MSTP support. Selection factors that determine which institutions are awarded MSTP grants (for example, the existence of active, high-quality research programs) and that determine which students at an MSTP institution receive support may also contribute to differences in outcomes between groups. These selection factors are confounding variables that make it difficult to estimate the extent to which differences in outcomes are attributable directly to the effects of the MSTP training experience itself.

[30] No difference is found between groups when the number of months of NIH predoctoral research training support is statistically controlled.

[31] In identifying candidates for the MSTP study and comparison groups, three data sets were used: the NIH Trainee-Fellow File; the National Research Council's Doctorate Record File; and data provided by the AAMC. As necessary, other sources were used (e.g., the Faculty Roster System developed by the AAMC). Quantum Research Corporation provided assistance in creating the study groups under contract N01-OD-2-2113, and the AAMC provided the data used to identify M.D. and M.D.-Ph.D. recipients under contract N01-OD-2-2112.

[32] These included bioengineering and all other fields not classified as in the biomedical sciences (e.g., chemistry, psychology, and economics).

APPENDICES

Appendix I
Academic Department Classifications

Departments Classified as Basic

Anatomy
Bacteriology
Biochemistry
Bioengineering and Biomedical Engineering
Biological Sciences, General
Biological Sciences, Other
Biophysics
Cell Biology
Chemical Engineering
Chemistry, General
Developmental Biology/Embryology
Ecology
Endocrinology
Genetics, Human and Animal
Immunology
Medicinal/Pharmaceutical Chemistry
Microbiology
Molecular Biology
Neuroscience
Other Physical Sciences
Parasitology
Pathology
Pathology, Human and Animal
Pharmacology, Human and Animal
Pharmacy
Physiology, Human and Animal
Toxicology
Zoology

Departments Classified as Clinical

Anesthesiology
Community Health
Dentistry
Dermatology
Emergency Medicine
Family Practice
General Surgery
Medicine
Neurology
Neurosurgery
Obstetrics/Gynecology
Ophthalmology
Orthopedic Surgery
Otolaryngology
Pediatrics
Plastic Surgery
Physical Medicine
Preventive Medicine
Psychiatry
Public Health
Radiology
Thoracic/Cardiovascular Surgery
Urology
Veterinary Medicine
Other Clinical Sciences

Other Unclassified Departments

Biometrics and Biostatistics
Epidemiology
Psychology
Statistics
Other Fields

Appendix II
Methods

Construction of the Study and Comparison Groups

Prior to conducting the study, a small pilot study was initiated to examine the feasibility of the planned study design in terms of identifying comparison groups, obtaining current addresses, soliciting *curricula vitae*, and extracting the necessary information. This effort involved selecting a random sample of MSTP-supported M.D.-Ph.D. recipients, stratified by Ph.D. cohort, and locating a comparable sample of Ph.D. recipients who had received NIH research training support and who matched each MSTP graduate on relevant characteristics. The results of the pilot study guided the final study design in several ways; for example, the diversity of available specializations included in the broad field of economics (labor economics, microeconomics, etc.) suggested disciplines whose graduates should not be included in the study due to the difficulty of identifying through extant data an appropriate match for an MSTP graduate with an M.D. and a Ph.D. in health economics.

The full study group population included all individuals who had been MSTP trainees and who met certain criteria: 1) they received at least 12 months of MSTP support, 2) their first year of MSTP support occurred no earlier than July 1969, and 3) both the M.D. and Ph.D. degrees were awarded by June 1990.[31] In addition, other criteria were applied in order to aid in the construction of appropriate comparison groups. First, in order that the M.D.-Ph.D. comparison groups consisted of individuals graduating from dual-degree *programs*, both degrees had to be awarded by the same institution and be coterminous (i.e., the Ph.D. had to be awarded no more than 3 years prior to the M.D. or no more than 2 years after the M.D.). Finally, individuals whose Ph.D.s were earned in disciplines that accounted for very small numbers of dual-degree recipients were excluded from the study.[32]

Because a large number of *curricula vitae* were successfully obtained for the individuals chosen for the pilot study, those who had provided their *curricula vitae* were retained in the final samples of MSTP and Ph.D. graduates. Additional individuals were then selected (randomly or by matching) until the desired sample size was achieved.

Comparison Groups

Four comparison groups were constructed as follows:

> **MSTP M.D. Only** (n=269). This group consisted of all MSTP participants who earned the M.D. but did not complete the Ph.D. degree. Because the number in each cohort[13] was relatively small, all identified individuals were included in the study. Comparison of this group to MSTP graduates provides an assessment of the relationship between Ph.D. completion and career outcomes.

Ph.D. Graduates (n =398). This group included Ph.D. recipients who had received at least 12 months of non-MSTP predoctoral research training support from NIH. For each of the sampled MSTP graduates, a Ph.D. recipient was selected who matched the MSTP graduate based on: 1) Ph.D.-granting institution, 2) year of receipt of Ph.D. degree, 3) field of Ph.D. degree, and 4) gender. Because it was not always possible to locate an exact match, the following strategy was used:

1) Based on the study design and previous literature on careers, the matching variables of the Ph.D. institution and gender were assumed to be of primary importance and were the first criteria to be satisfied in locating a match for a specific MSTP graduate.

2) When a match was available by institution, gender, and Ph.D. year (the academic year from July through June) but not by Ph.D. field, an individual in a closely related field who matched on all other criteria was sought first. This required some "clustering" of fields: 1) cellular biology, molecular biology, and biochemistry, 2) microbiology and immunology (and cellular/molecular biology if no matches were found), 3) general biological sciences and other biological sciences, 4) general health sciences and other health sciences, 5) and physiology and biophysics.

3) When all criteria matched except the date of receipt of Ph.D. degree, the next step was to identify an individual whose Ph.D. degree was awarded "just outside" the academic year of the MSTP graduate. To illustrate, if the MSTP graduate received a Ph.D. degree in biochemistry in June 1985 and there were no corresponding individuals in the Ph.D. graduate population from that institution, a search was conducted for a person who received the Ph.D. in another academic year (but still within 11 months of the date of the MSTP graduate's degree). This approach was not used when relaxing of this criterion would cross Ph.D. cohorts, although it was impossible to avoid in a very small number of cases. In addition, for another few cases, extending the 11-month criterion was necessary in order to locate a match on all other variables.

4) If all the above procedures yielded no matching candidates, an individual who matched on all variables except Ph.D. field was chosen. For example, the match for a female MSTP graduate with a Ph.D. degree in pathology from Institution A in 1984 was another female who earned her Ph.D. degree in 1984 from Institution A, but in the field of genetics.

For the most part, this strategy resulted in locating a "match" Ph.D. for the large majority of MSTP graduates in the sample (97 percent). Those MSTP graduates for whom a match could not be found were all members of the 1971-75 cohort.

An examination of the quality of the matches—prior to any reassignment based on information contained in the *curricula vitae*—revealed that 69.2 percent of sampled MSTP trainees had a Ph.D. who matched on all criteria. Another 26.8 percent had a match on all variables except field of Ph.D. degree, 2.3 percent did not match on year of receipt of Ph.D. degree, and 1.8 percent did not match on Ph.D. field or year of receipt of degree.

This comparison group was intended to permit the examination of similarities and differences in outcomes for individuals whose *research* training was similar to that of MSTP graduates in terms of disciplinary focus and institutional environment, but was dissimilar because it did not include clinical emphases and skills.

Non-MSTP M.D.-Ph.D.s from MSTP Institutions (n = 314). This group included all M.D.-Ph.D.-degree holders who graduated from the same institutions as the MSTP graduates, with coterminous degrees, but who did not receive MSTP support. Comparison to this group was intended to assess whether selection and participation as an MSTP trainee is associated with a different career progression than that of individuals with similar training experiences but no MSTP support. All individuals meeting these criteria were included in the study. No individuals from the earliest cohort (1971-75) were identified.[17]

M.D.-Ph.D.s from Non-MSTP Institutions (n = 314). This group included individuals with coterminous M.D. and Ph.D. degrees from institutions without MSTP training programs. This group was used to compare outcomes of MSTP graduates with dual-degree recipients at institutions without MSTP training programs. No individuals were identified from the 1971-75 cohort. The study included a random sample of the 380 individuals who were identified.

Some reassignments of individuals among study groups were necessary as a result of more complete information on degree status contained in the *curricula vitae* collected from study participants. For example, 25 individuals originally in the MSTP M.D. only group were found to have received Ph.D. degrees and were either reassigned to the MSTP graduates group or were excluded from the study for not having received coterminous degrees by 1990.

Methods of *Curricula Vitae* Collection

Several mechanisms were used to locate the MSTP and comparison group members selected for the study. First, the NIH database of applicants for grant support was used to locate a large number of individuals. Second, all current MSTP program directors were contacted for assistance in locating the selected graduates of their institutions. In addition, the program directors were asked for help in locating the individuals from the comparison groups from their institutions. With the exception of two programs, all MSTP institutions supplied the most recent phone numbers and/or addresses they had on file for the graduates. The directors of a number of

the M.D.-Ph.D. programs at non-MSTP institutions supplied location information for the selected graduates of those institutions. Individuals were also located using a number of membership databases available online (American Medical Association, Federation of American Societies for Experimental Biology, American Society for Microbiology, Association of American Medical Colleges, and Society for Neuroscience), publication information available through MEDLINE, and "people" search sites on the Internet.

Data Analyses

The conclusions in this report were based on pairwise comparisons of the MSTP graduate group to each of the four comparison groups. Two principal methods of analysis were used to perform these comparisons: multiple regression was used when the dependent variable was continuous (e.g., number of publications), and logistic regression was used when the dependent variable was dichotomous (e.g., receipt of research grant support). The independent variables used in each analysis were cohort and group (the latter being a dichotomous variable indicating whether an individual was an MSTP graduate or a member of one of the comparison groups). Group differences in the time-to-degree data were analyzed using the Mann-Whitney U statistic. All conclusions were based on a 0.05 level of statistical significance.

When there were between-group differences in demographic or other variables (e.g., length of NIH training support) that might also have some relationship to an outcome variable, these other factors were controlled for in the analyses using a hierarchical regression approach. In general, such factors had little effect on the outcomes of the analyses.

Appendix III
Definitions and Criteria Used in Analyses of *Curricula Vitae*

Postdoctoral Research Training Support. This included training that was identified on the *curriculum vitae* as postdoctoral training or was associated with such titles as postdoctoral research fellow, research associate, or staff fellow (e.g., for NIH intramural positions). This training had to last for 9 or more months. In identifying the organization supporting the postdoctoral training, more than one source was possible, and determining the type of sponsoring organization was done by consulting lists of available postdoctoral awards and programs in the biomedical sciences. The various types of postdoctoral training sponsors were: 1) NIH (through both extramural and intramural postdoctoral traineeships and fellowships; clinical investigator, physician-scientist, or similar research career development awards were excluded); 2) other federal agencies (e.g., the National Science Foundation and the Department of Veterans Affairs); 3) private industry (e.g., Bell Laboratories); 4) private foundations (e.g., postdoctoral awards funded by the American Cancer Society, the Damon Runyon-Walter Winchell Foundation, the Howard Hughes Medical Institute, and the Lucille P. Markey Charitable Trust); and 5) other sources, which most typically were faculty research grants or institutional funds.

Clinical Fellowships. This included training that was typically listed in the *curriculum vitae* in a section on postdoctoral or postgraduate training and was labeled as a clinical fellowship in a specialty (e.g., gastroenterology, infectious diseases, and rheumatology). This fellowship also had to be 9 or more months in duration. NIH intramural clinical associate positions were considered as both clinical fellowships and postdoctoral research training, given that they frequently provided both types of experiences.

Source of Research Support. This included the receipt by the individual of grants and contracts for carrying out research; support for training programs, predoctoral/postdoctoral fellows, instructional activities, and equipment were not included. Only awards made after the completion of postdoctoral research and clinical training and before 1996 were included. The type of sponsoring organization was also classified, and outside sources (e.g., foundation grant directories) were consulted when questions arose. The types of sponsoring organizations were: 1) NIH, including research grants and research career development awards; 2) other federal agencies (e.g., the National Science Foundation, the Department of the Army, the Department of Energy, and the Department of Veterans Affairs); 3) industry (e.g., Abbott Laboratories, General Electric Company, Glaxo Wellcome Inc., and Bristol-Myers Squibb Company); 4) private foundations (e.g., the American Heart Association and affiliates, the Muscular Dystrophy Association, the American Cancer Society, and the McKnight Foundation); and 5) other organizations (e.g., state departments of health). The last category also included grants made by institutional committees using NIH Biomedical Research Support Grants or American Cancer Society institutional grant funds.

Employment. To be included in the analyses, the employment had to occur after the completion of all postdoctoral research and clinical training and had to begin no later than 1995. When

appropriate, multiple positions were included (e.g., clinical associate professor at a university and staff physician at a VA hospital). Temporary appointments such as a 12-month position as a visiting scientist while on sabbatical were excluded, as well as those that were part of the individual's responsibilities in the primary position (e.g., a professor who also is director of graduate studies of the department).

Clinical Activities. For clinical activities to be included, the individual had to be involved in some type of patient care role, either full-time or part-time. Such participation did not include responsibilities as an intern, resident, or clinical fellow. Examples included faculty members who were attending physicians at an associated teaching hospital and/or who indicated regular participation in grand rounds, physicians in independent or group medical practices, and staff hospital positions (e.g., staff surgeons or pathologists).

Type of Journal. To be counted as a publication, an article had to have appeared no later than 1995 ("in press" articles were not counted). Both peer-reviewed and invited articles and reviews were included, although entries identified by the individual as an editorial, letter to the editor, or book review were excluded. The article also had to appear in one of the journals indexed by the Institute for Scientific Information and included in its *Current Contents Journal Coverage as of January 1996*. The use of this last criterion allowed classification of the article as being focused on (or of interest to) research in the basic sciences (including the life, agricultural, biological, environmental, physical, engineering, or computing sciences), clinical medicine, or both. It also represented a crude cut at journal quality, given that the listed journals were chosen by the ISI on the basis of editorial board review, evaluation of content and format by journal experts, and statistical analyses of the impact and use of the published material. Among the journals in each category were:

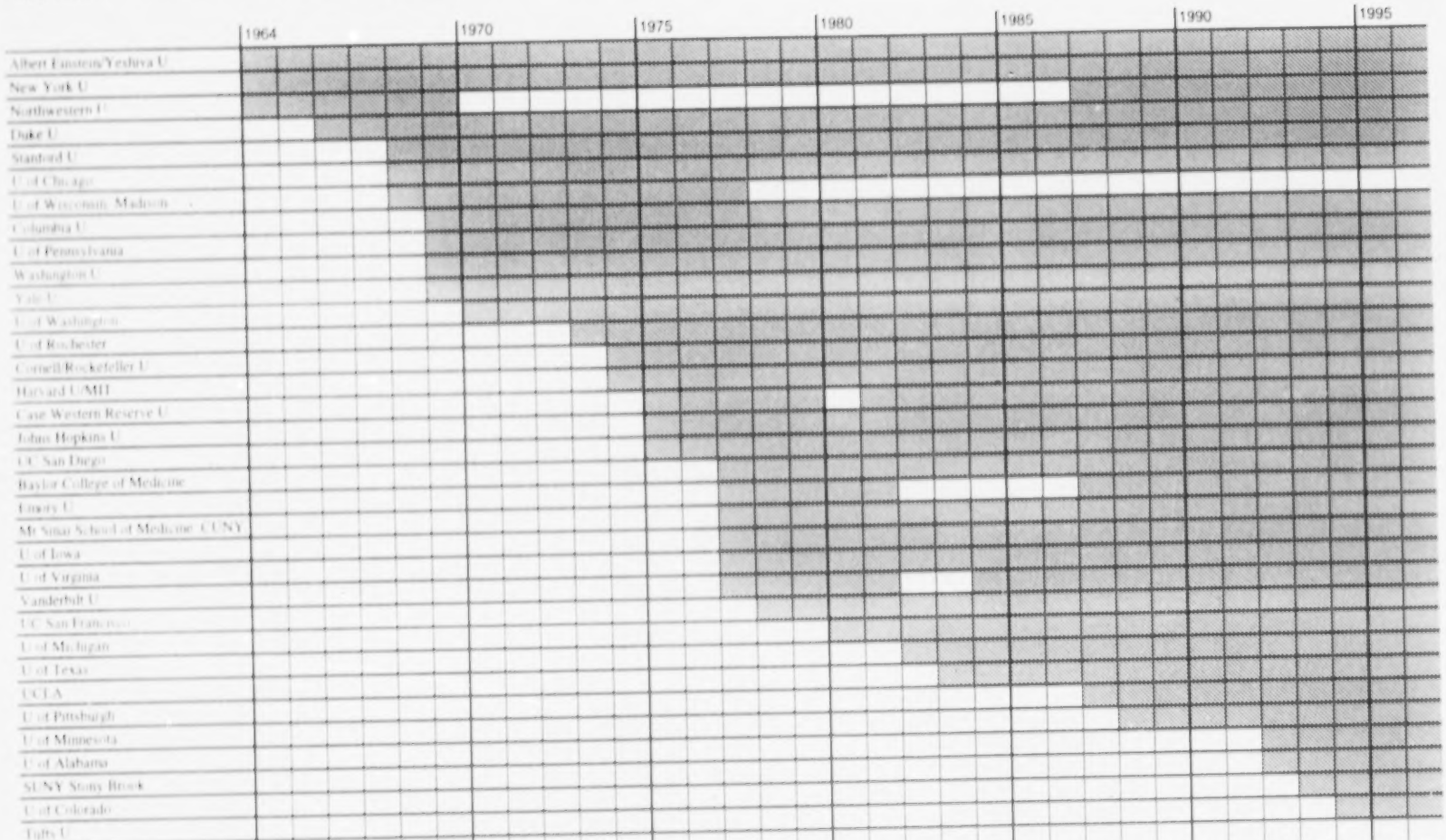
Basic: *American Journal of Physiology, Circulation Research, Endocrinology, Journal of Biological Chemistry, Journal of Clinical Investigation, Journal of Reproduction and Fertility, Proceedings of the National Academy of Sciences, Psychiatry Research, Science,* and *Transplantation.*

Clinical: *American Journal of Gastroenterology, British Journal of Urology, Clinical Neurology and Neurosurgery, Critical Care Medicine, Cytopathology, Journal of Epilepsy, Journal of Nephrology, Journal of Surgical Oncology, Pediatric Annals,* and *Texas Heart Institute Journal.*

Mixed Types: *American Journal of Medicine; Clinical Immunology and Immunopathology; Human Pathology; International Journal of Radiation Oncology, Biology, and Physics; Journal of the American Medical Association; Journal of Clinical Microbiology; Ophthalmology; Pediatrics; Seminars in Oncology;* and *Transfusion.*

Appendix IV
Statistical Tables

Appendix Table 1. MSTP Funding History


1964
1970
1975
1980
1985
1990
1995
Albert Einstein/Yeshiva U
New York U
Northwestern U
Duke U
Stanford U
U of Chicago
U of Wisconsin, Madison
Columbia U
U of Pennsylvania
Washington U
Yale U
U of Washington
U of Rochester
Cornell/Rockefeller U
Harvard U/MIT
Case Western Reserve U
Johns Hopkins U
UC San Diego
Baylor College of Medicine
Emory U
Mt Sinai School of Medicine, CUNY
U of Iowa
U of Virginia
Vanderbilt U
UC San Francisco
U of Michigan
U of Texas
UCLA
U of Pittsburgh
U of Minnesota
U of Alabama
SUNY Stony Brook
U of Colorado
Tufts U
Number of Trainees Supported 66 75 115 179 259 325 358 358 422 463 489 495 578 669 676 715 688 677 686 712 711 768 769 767 818 816 840 866 870 883 873
Number of New Trainees 66 26 47 78 96 106 86 53 111 125 106 142 148 168 157 125 129 143 158 164 149 201 173 183 200 209 217 212 224 219 242
= Funded Program

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Appendix Table 2. Original Study Sample.

Characteristic	MSTP Graduates		MSTP M.D. Only		Ph.D. Graduates		Non-MSTP M.D.-Ph.D.s			
							MSTP Institutions		Non-MSTP Institutions	
	N	%	N	%	N	%	N	%	N	%
Sample Size	410		269		398		314		314	
Sex										
Male	364	89 %	214	80 %	352	88 %	262	83 %	264	84 %
Female	46	11	55	20	46	12	52	17	50	16
Race/Ethnicity										
Asian/Pacific Islander	18	4	0	0	8	2	22	7	14	4
Black	5	1	7	3	0	0	11	4	3	1
Hispanic	36	9	18	7	1	0	5	2	2	1
White	331	81	192	71	349	88	276	88	293	93
Other/Unknown	20	5	52	19	40	10	0	0	2	1
Year of Ph.D.										
1971-75	51	12	32	12	38	10	n/a	n/a	n/a	n/a
1976-80	119	29	50	19	119	30	73	23	74	24
1981-85	120	29	104	39	120	30	121	39	119	38
1986-90	120	29	83	31	121	30	120	38	121	39
Field of Ph.D.										
Anatomy	14	3			11	3	19	6	26	8
Biochemistry	62	15			62	16	41	13	57	18
Cellular/Molecular Biology	60	15			80	20	43	14	17	5
Genetics	11	3			18	5	10	3	4	1
Microbiology/Immunology	55	13			53	13	30	10	35	11
Neuroscience	27	7			22	6	25	8	8	3
Pathology	28	7			15	4	30	10	24	8
Pharmacology	42	10			45	11	41	13	56	18
Physiology/Biophysics	64	16			46	12	42	13	70	22
General and Other Biological Sciences	30	7			38	10	19	6	10	3
General and Other Health Sciences	17	4			8	2	14	4	7	2

Appendix Table 2 (Cont'd.). Original Study Sample.

Characteristic	MSTP Graduates		MSTP M.D. Only		Ph.D. Graduates		Non-MSTP M.D.-Ph.D.s from MSTP Institutions	
	N	%	N	%	N	%	N	%
MSTP Institution*								
Albert Einstein/Yeshiva University	34	8.3 %	24	8.9 %	30	7.5 %	12	3.8 %
Baylor University	5	1.2	6	2.2	5	1.3	23	7.3
Case Western Reserve University	6	1.5	6	2.2	6	1.5	51	16.2
Columbia University	13	3.2	6	2.2	13	3.3	3	1.0
Cornell/Rockefeller University	14	3.4	6	2.2	14	3.5	23	7.3
Duke University	39	9.5	15	5.6	39	9.8	15	4.8
Emory University	2	0.5	0	0.0	2	0.5	10	3.2
Harvard University/MIT	23	5.6	19	7.1	23	5.8	8	2.5
Johns Hopkins University	11	2.7	14	5.2	11	2.8	16	5.1
Mt. Sinai School of Medicine/CUNY	6	1.5	2	0.7	6	1.5	0	0.0
New York University	38	9.3	21	7.8	38	9.5	2	0.6
Stanford University	25	6.1	20	7.4	26	6.5	29	9.2
U of California, San Diego	4	1.0	14	5.2	4	1.0	3	1.0
U of California, San Francisco	4	1.0	13	4.8	4	1.0	1	0.3
U of Chicago	38	9.3	19	7.1	37	9.3	0	0.0
U of Iowa	3	0.7	4	1.5	3	0.8	18	5.7
U of Michigan	1	0.2	5	1.9	0	0.0	8	2.5
U of Pennsylvania	28	6.8	12	4.5	27	6.8	9	2.9
U of Rochester	12	2.9	3	1.1	12	3.0	13	4.1
U of Virginia	6	1.5	4	1.5	6	1.5	7	2.2
U of Washington	15	3.7	9	3.3	15	3.8	4	1.3
U of Wisconsin, Madison	3	0.7	1	0.4	3	0.8	8	2.5
Vanderbilt University	5	1.2	7	2.6	5	1.3	15	4.8
Washington University	49	12.0	14	5.2	43	10.8	23	7.3
Yale University	26	6.3	25	9.3	26	6.5	13	4.1
Months of Predoctoral Training Support								
Mean	62		36		40			
Median	69		31		37			

* The following MSTP institutions (primarily the most recent to receive MSTP support) were excluded from the sampling frame because they had no graduates or only one graduate by 1990: State University of New York at Stony Brook; University of Alabama at Birmingham; University of Colorado Health Sciences Center; University of Minnesota; University of Pittsburgh; University of Texas Health Science Center at Dallas; and University of California, Los Angeles. In addition, Northwestern University had two MSTP grants. The first one ended in 1969 and resulted in no graduates meeting the criterion of 1970 as the first year of MSTP support. The second grant was awarded in 1987 and no graduates of this program met the criterion of receiving both degrees by June 1990.

Appendix Table 3. Sample of *Curriculum Vitae* Respondents.

Characteristic	MSTP Graduates		MSTP M.D. Only		Ph.D. Graduates		Non-MSTP M.D.-Ph.D.s			
							MSTP Institutions		Non-MSTP Institutions	
	N	%	N	%	N	%	N	%	N	%
Sample Size	346		138		258		201		169	
Sex										
Male	309	89 %	111	80 %	227	88 %	171	85 %	138	82 %
Female	37	11	27	20	31	12	30	15	31	18
Race/Ethnicity										
Asian/Pacific Islander	17	5	0	0	5	2	13	6	5	3
Black	5	1	2	1	0	0	4	2	2	1
Hispanic	30	9	14	10	1	0	3	1	1	1
White	277	80	96	70	229	89	181	90	160	95
Other/Unknown	17	5	26	19	23	9	0	0	1	1
Year of Ph.D.										
1971-75	43	12	21	15	21	8	n/a	n/a	n/a	n/a
1976-80	89	26	27	20	76	29	42	21	35	21
1981-85	103	30	53	38	81	31	71	35	66	39
1986-90	111	32	37	27	80	31	88	44	68	40
Field of Ph.D.										
Anatomy	11	3			6	2	10	5	13	8
Biochemistry	54	16			43	17	24	12	32	19
Cellular/Molecular Biology	51	15			57	22	31	15	9	5
Genetics	11	3			12	5	7	3	2	1
Microbiology/Immunology	46	13			29	11	25	12	21	12
Neuroscience	26	8			14	5	17	8	4	2
Pathology	22	6			8	3	13	6	15	9
Pharmacology	33	10			31	12	29	14	33	20
Physiology/Biophysics	53	15			31	12	24	12	35	21
General and Other Biological Sciences	26	8			24	9	13	6	3	2
General and Other Health Sciences	13	4			3	1	8	4	2	1

Appendix Table 3 (Cont'd.). Sample of *Curriculum Vitae* Respondents.

Characteristic	MSTP Graduates		MSTP M.D. Only		Ph.D. Graduates		Non-MSTP M.D.-Ph.D.s from MSTP Institutions	
	N	%	N	%	N	%	N	%
MSTP Institution								
Albert Einstein/Yeshiva University	21	6.1 %	8	5.8 %	16	6.2 %	4	2.0 %
Baylor University	5	1.4	3	2.2	3	1.2	17	8.5
Case Western Reserve University	3	0.9	1	0.7	6	2.3	24	11.9
Columbia University	11	3.2	5	3.6	8	3.1	3	1.5
Cornell/Rockefeller University	10	2.9	2	1.4	5	1.9	13	6.5
Duke University	35	10.1	7	5.1	24	9.3	7	3.5
Emory University	1	0.3	0	0.0	1	0.4	6	3.0
Harvard University/MIT	25	7.2	8	5.8	18	7.0	8	4.0
Johns Hopkins University	13	3.8	7	5.1	8	3.1	13	6.5
Mt. Sinai School of Medicine/CUNY	6	1.7	1	0.7	3	1.2	1	0.5
New York University	31	9.0	13	9.4	24	9.3	2	1.0
Stanford University	25	7.2	13	9.4	21	8.1	26	12.9
U of California, San Diego	3	0.9	6	4.3	1	0.4	1	0.5
U of California, San Francisco	4	1.2	8	5.8	2	0.8	0	0.0
U of Chicago	31	9.0	7	5.1	21	8.1	3	1.5
U of Iowa	3	0.9	4	2.9	3	1.2	14	7.0
U of Michigan	2	0.6	2	1.4	0	0.0	7	3.5
U of Pennsylvania	22	6.4	7	5.1	16	6.2	5	2.5
U of Rochester	11	3.2	2	1.4	9	3.5	9	4.5
U of Virginia	6	1.7	1	0.7	5	1.9	4	2.0
U of Washington	12	3.5	3	2.2	12	4.7	2	1.0
U of Wisconsin, Madison	1	0.3	1	0.7	2	0.8	3	1.5
Vanderbilt University	3	0.9	4	2.9	1	0.4	8	4.0
Washington University	41	11.8	8	5.8	31	12.0	16	8.0
Yale University	21	6.1	17	12.3	18	7.0	5	2.5
Months of Predoctoral Training Support								
Mean	62		31		39			
Median	69		28		36			

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Appendix Table 4. Availability of *Curriculum Vitae* Data, by Group (After Group Reassignments).

Group	Vitae Received	As % of Sample
MSTP Graduates	346	83.8%
MSTP M.D. Only	138	56.8
Ph.D. Graduates	258	68.8
Non-MSTP M.D.-Ph.D.s from MSTP Institutions	201	62.8
M.D.-Ph.D.s from Non-MSTP Institutions	169	54.2
Total	1112	66.9

Appendix Table 5. Publication Summary Statistics.

Total Publications						
Cohort		MSTP Graduates	MSTP M.D. Only	Ph.D. Graduates	Non-MSTP M.D.-Ph.D.s	
					MSTP Institutions	Non-MSTP Institutions
1975	Mean	51.2	30.6	43.6	*	*
	Std Dev	38.3	31.9	31.5		
	Median	45.5	22.0	47.0		
1980	Mean	46.8	17.4	36.3	32.9	18.8
	Std Dev	38.9	31.1	33.7	29.4	21.6
	Median	37.5	5.0	29.0	27.0	13.0
1985	Mean	25.0	14.2	21.1	21.8	14.8
	Std Dev	20.1	18.3	15.3	22.5	17.2
	Median	17.0	5.0	18.0	15.0	10.5
1990	Mean	13.5	4.1	12.7	11.0	10.2
	Std Dev	12.5	5.7	12.4	11.6	10.8
	Median	11.0	2.0	10.5	9.0	8.0
Publications in 1993-1995						
Cohort		MSTP Graduates	MSTP M.D. Only	Ph.D. Graduates	Non-MSTP M.D.-Ph.D.s	
					MSTP Institutions	Non-MSTP Institutions
1975	Mean	8.5	4.6	5.0	*	*
	Std Dev	7.8	4.8	4.7		
	Median	7.0	2.0	4.0		
1980	Mean	12.2	3.4	6.8	8.3	4.8
	Std Dev	16.3	6.2	8.7	8.8	6.8
	Median	7.0	0.0	4.0	6.0	2.0
1985	Mean	8.4	5.3	5.6	6.7	4.6
	Std Dev	8.3	9.0	5.5	8.1	6.4
	Median	6.0	1.0	4.0	4.0	3.0
1990	Mean	4.5	1.9	3.7	3.5	3.7
	Std Dev	5.3	5.0	4.4	5.5	6.0
	Median	3.0	0.0	2.0	2.0	2.0

* No 1975 cohort

Appendix Table 6. Employment in 1995, by Type of Organization.

Type of Organization	MSTP Graduates	MSTP M.D. Only	Ph.D. Graduates	Non-MSTP M.D.-Ph.D.s	
				MSTP Institutions	Non-MSTP Institutions
1975 Cohort					
Academia	83%	80%	81%	*	*
Hospital/Clinic	52	60	0		
Private Industry	7	5	19		
Self Emp/Priv Practice	12	20	5		
Other	5	5	5		
1980 Cohort					
Academia	76	52	68	68%	63%
Hospital/Clinic	57	68	7	47	53
Private Industry	13	8	27	5	3
Self Emp/Priv Practice	11	36	3	18	41
Other	3	4	14	5	0
1985 Cohort					
Academia	87	75	60	80	72
Hospital/Clinic	52	57	0	52	59
Private Industry	4	6	35	3	7
Self Emp/Priv Practice	5	27	0	14	21
Other	8	6	10	12	0
1990 Cohort					
Academia	90	50	64	84	67
Hospital/Clinic	47	46	4	49	48
Private Industry	1	4	30	2	2
Self Emp/Priv Practice	4	42	1	9	17
Other	10	0	7	9	6
Overall					
Academia	84	66	65	78	68
Hospital/Clinic	52	57	3	50	54
Private Industry	6	6	30	3	4
Self Emp/Priv Practice	8	31	2	13	24
Other	7	4	10	9	2

* No 1975 cohort

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